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Patentanmeldung Nr. Patent application No. Demande de brevet n°

03252485.2

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R C van Dijk



Anmeldung Nr:  
Application no.: 03252485.2  
Demande no:

Anmeldetag:  
Date of filing: 17.04.03  
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

SHELL INTERNATIONALE RESEARCH  
MAATSCHAPPIJ B.V.  
Carel van Bylandtlaan 30  
2596 HR Den Haag  
PAYS-BAS

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:  
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A process for the removal of H<sub>2</sub>S and mercaptans from a gas stream

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s)  
revendiquée(s)

Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/  
Classification internationale des brevets:

B01D53/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of  
filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL  
PT RO SE SI SK TR LI

A PROCESS FOR THE REMOVAL OF H<sub>2</sub>S AND MERCAPTANS FROM A  
GAS STREAM

FIELD OF THE INVENTION

The invention relates to a process for removing H<sub>2</sub>S and mercaptans from a gas stream comprising these compounds.

5       The invention further relates to a gas-treating unit for the removal of H<sub>2</sub>S and mercaptans from a gas stream comprising these compounds in a process according to the invention.

BACKGROUND OF THE INVENTION

10       The removal of H<sub>2</sub>S and mercaptans from a gas stream comprising these compounds is of considerable importance, because the toxicity and smell of H<sub>2</sub>S and mercaptans renders their presence highly undesirable. Moreover, H<sub>2</sub>S is very corrosive to the gas pipeline network. In view of  
15       the increasingly stringent environmental requirements, removal of H<sub>2</sub>S and mercaptans has become even more important.

20       A number of processes are known in the art for the removal of H<sub>2</sub>S from gas streams. These processes are based on physical and/or chemical absorption, chemical reaction and/or solid bed adsorption. Physical and/or chemical absorption processes, often using aqueous alkaline solutions, usually are able to remove the H<sub>2</sub>S to  
25       a large extent. In some cases even complete removal of the H<sub>2</sub>S is attained. However, the removal of mercaptans to a low level in a gas stream wherein both mercaptans

and  $H_2S$  are present is much more difficult. Chemically reacting processes in general are able to remove  $H_2S$  without large difficulties; however, they suffer from the drawback that they do not effectively remove mercaptans, sulphides and disulfides and often produce large amounts of useless waste (such as non-regenerable adsorbents).

Processes known in the art include treating the gas stream with an alkaline aqueous liquid, as described for instance in EP 331,806 and EP 229,587. A drawback of this method is the high consumption of alkaline chemicals needed to remove the  $H_2S$ . In WO 92/10270, a process is described for the removal of sulphur compounds from gases wherein the gas is washed with an aqueous washing liquid and the washing liquid is subjected to sulphide-oxidising bacteria. The process described in WO 92/10270 is said to be suitable for the removal of lower alkyl mercaptans as well. A disadvantage of the process described in WO 92/10270 is that in the presence of mercaptans, a high consumption of alkaline would be required to remove both the  $H_2S$  and the mercaptans from the gas stream.

We have now found a relatively simple and inexpensive process to remove both  $H_2S$  and mercaptans from a gas stream comprising these compounds. In the process according to the invention,  $H_2S$  and mercaptans are separately converted to their corresponding sulphide compounds, followed by biological oxidation of the hydrogen sulphide to elemental sulphur. The process according to the invention allows the removal of both  $H_2S$  and mercaptans from a gas stream comprising these compounds, to levels of below 10 ppmv for  $H_2S$  and below 6 ppmv for mercaptans.

SUMMARY OF THE INVENTION

The invention relates to a process for the removal of  $H_2S$  and mercaptans from a gas stream comprising these compounds, which process comprises the steps of:

5 (a) removing  $H_2S$  from the gas stream by contacting the gas stream in a  $H_2S$ -removal zone with a first aqueous alkaline washing liquid to obtain a  $H_2S$ -depleted gas stream and a sulphide-comprising aqueous stream;

10 (b) removing mercaptans from the  $H_2S$ -depleted gas stream obtained in step (a) by contacting the  $H_2S$ -depleted gas stream in a mercaptan-removal zone with a second aqueous alkaline washing liquid to obtain a mercaptan-depleted gas stream and a hydrocarbylsulphide-comprising aqueous stream;

15 (c) contacting the combined aqueous streams comprising sulphide and hydrocarbylsulphides obtained in step (a) and step (b) with sulphide-oxidizing bacteria in the presence of oxygen in an oxidation reactor to obtain a sulphur slurry and a regenerated aqueous alkaline washing liquid;

20 (d) separating at least part of the sulphur slurry obtained in step (c) from the aqueous alkaline washing liquid; and

25 (e) recycling the regenerated aqueous alkaline washing liquid obtained in step (c) to the  $H_2S$ -removal zone in step (a) and to the mercaptan-removal zone in step (b).

In the case that the gas stream in addition to  $H_2S$  and mercaptans also contains  $CO_2$ , at least part of the  $CO_2$  will also be removed.

30 The invention further relates to a gas-treating unit for the removal of  $H_2S$  and mercaptans and from a gas

stream comprising these compounds in a process according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

5 In step (a) of the process according to the invention the gas stream is contacted with an aqueous alkaline washing liquid in a H<sub>2</sub>S-removal zone in order to remove the H<sub>2</sub>S from the gas stream to obtain a H<sub>2</sub>S-depleted gas stream and a sulphide-comprising aqueous stream.

10 Suitable aqueous alkaline washing liquids include aqueous hydroxide solutions, e.g. sodium hydroxide or potassium hydroxide solutions in water and aqueous (bi)carbonate solutions.

15 The starting gas stream may contain any amount of H<sub>2</sub>S and mercaptans compounds, but in general, the total concentration of H<sub>2</sub>S will be between 50 ppmv up to 90 vol%, preferably between 100 ppmv and 70 vol%, more preferably between 150 ppmv and 50 vol%, still more preferably between 200 ppmv and 20 vol%, based on the total gas stream. The total amount of mercaptans in the  
20 starting gas stream is typically between 10 up to 1000 ppmv, based on the total gas stream.

Suitably, the hydrogen sulphide load in the H<sub>2</sub>S-removal zone is between 50 and 100000 kg/day, preferably between 100 and 50000 kg/day.

25 The main reactions that can take place in the H<sub>2</sub>S-removal zone in step (a) are:

- |                                  |  |
|----------------------------------|--|
| (1) H <sub>2</sub> S absorption  | $\text{H}_2\text{S} + \text{OH}^- \rightarrow \text{HS}^- + \text{H}_2\text{O}$  |
| (2) H <sub>2</sub> S absorption  | $\text{H}_2\text{S} + \text{CO}_3^{2-} \rightarrow \text{HS}^- + \text{HCO}_3^-$ |
| (3) CO <sub>2</sub> absorption   | $\text{CO}_2 + \text{OH}^- \rightarrow \text{HCO}_3^-$                           |
| (4) Poly-hydrosulphide formation | $2\text{HS}^- + \text{S}_8 \rightarrow 2\text{HS}_5^-$                           |

The term sulphide-comprising aqueous streams as used herein refers to an aqueous stream comprising one or more products of the main reactions 1 to 4 that can take place in the H<sub>2</sub>S-removal zone, such as HS<sup>-</sup>, disulphides, polysulphides, thiocarbonates and carbonates but can also include dissolved H<sub>2</sub>S.

Reference herein to "H<sub>2</sub>S-depleted gas stream" is to a gas stream wherein the H<sub>2</sub>S concentration is between 0.01 and 100 ppmv, especially below 10 ppmv, suitably between 0.02 and 3.5 ppmv, preferably between 0.05 and 3 ppmv, more preferably between 0.1 and 1 ppmv, based on the total gas stream. The mercaptan concentration in the H<sub>2</sub>S-depleted gas stream is typically between 10 ppmv and 0.1 vol%, based on the total H<sub>2</sub>S-depleted gas stream.

The preferred temperature in the H<sub>2</sub>S removal zone is between 5 and 70 °C, more preferably between 10 and 50 °C. Preferably, the pressure in the H<sub>2</sub>S removal zone is between 1 and 100 bar(g), more preferably between 1.5 and 80 bar(g).

Step (b) of the process according to the invention is concerned with the removal of mercaptans from the H<sub>2</sub>S-depleted gas stream obtained from the step (a) by contacting the H<sub>2</sub>S-depleted gas stream in a mercaptan-removal zone with other aqueous alkaline washing liquid to obtain a mercaptan-depleted gas stream and a hydrocarbylsulphide-comprising aqueous stream.

Reference herein to mercaptans is to aliphatic mercaptans, especially C<sub>1</sub>-C<sub>6</sub> mercaptans, more especially C<sub>1</sub>-C<sub>4</sub> mercaptans, aromatic mercaptans, especially phenyl mercaptan, or mixtures of aliphatic and aromatic mercaptans.

The invention especially relates to the removal of methyl mercaptan, ethyl mercaptan, normal- and iso-propyl mercaptan and butyl mercaptan isomers.

The main reactions that can take place in the mercaptan-removal zone in step (b) are:



formation

wherein R can be an alkyl substituent, especially methyl, ethyl, propyl or butyl or an aromatic substituent, especially phenyl, or mixtures thereof.

The term hydrocarbylsulphide-comprising aqueous streams as used herein refers to an aqueous stream comprising one or more products of the main reactions 5 to 8 that can take place in the mercaptan-removal zone, and can include dissolved RSH.

The preferred temperature in the mercaptan removal zone is between 5 and 70 °C, more preferably between 10 and 50 °C. Preferably, the pressure in the H<sub>2</sub>S removal zone is between 1 and 100 bar(g), more preferably between 1.5 and 80 bar(g).

Typically, a gas/liquid contactor is used as the H<sub>2</sub>S removal zone and/or the mercaptan removal zone. Suitable gas/liquid contactors are described in Perry's Chemical Engineers' Handbook, 7<sup>th</sup> edition, section 14 (1997) and



include for example a tray or packed column or a gas scrubber.

5       Reference herein to a mercaptan-depleted gas stream is to a gas stream wherein the concentration of both  $H_2S$  and the mercaptans has been reduced to a level which is acceptable for the intended purpose of the gas stream.

10       The mercaptan-depleted gas stream can be processed further in known manners, for example by catalytic or non-catalytic combustion, to generate electricity, heat or power, or as a feed gas for a chemical reaction or for residential use.

15       Due to their odorous nature,  $H_2S$ , mercaptans, sulphides, disulphides and aromatic mercaptans can be detected at parts per million concentration levels. Thus, it is desirable for users of such gas streams, especially in the case where the gas stream is intended for residential use, to have concentrations of total sulphur compounds lowered to a level of e.g. less than 30 or 20 ppmv, preferably less than 10 ppmv, especially between 20       0.01 and 10 ppmv, preferably between 0.05 and 3.5 ppmv, more preferably between 0.1 and 1 ppmv, based on the total mercaptan-depleted gas stream. The concentration of mercaptan compounds is preferably lowered to e.g. less than 6 ppmv, or less than 4 ppmv, preferably less than 25       2 ppmv, based on the total mercaptan-depleted gas stream.

30       Optionally, the washing liquid of the  $H_2S$  removal zone or the washing liquid of the mercaptan removal zone is buffered, or both washing liquids are buffered. Preferred buffering compounds are carbonates, bicarbonates phosphates and mixtures thereof, especially sodium carbonate and/or sodium bicarbonate.

      The concentration of the buffering compounds depends inter alia on the composition of the gas flow and is

generally adjusted in such a way, that the washing liquid is kept within the preferred pH range.

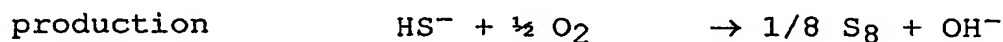
Preferably, the pH of the washing liquid in the H<sub>2</sub>S removal zone in step (a) is between 4.5 and 10, more preferably between 5.5 and 9.

Preferably, the pH of the washing liquid in the mercaptan removal zone is between 5.5 and 10, more preferably between 6.5 and 9.

In step (c) of the process according to the invention, the sulphide-containing and hydrocarbylsulphide-comprising aqueous streams obtained from the first and second step are optionally combined and contacted with sulphide-oxidizing bacteria in the presence of oxygen in a oxidation reactor to obtain a sulphur slurry and a regenerated aqueous alkaline washing liquid.

The main reaction that can take place in the oxidation reactor in step (c) is the microbiological formation of sulphur and sulphate:

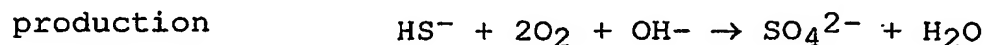
(9a) Sulfur



(9b) Sulfur



(10) Sulphate



The term sulphur slurry as used herein refers to a slurry comprising one or more products of the main reactions, including reactions (9a), (9b) and (10), that can take place in the oxidation reactor.

The term regenerated aqueous alkaline washing liquid as used herein refers to a regenerated aqueous alkaline washing liquid comprising sulphur particles.

Reference herein to sulphide-oxidising bacteria is to bacteria which can oxidise sulphide to elemental sulphur. Suitable sulphide-oxidising bacteria can be selected for instance from the known autotropic aerobic cultures of the genera Thiobacillus and Thiomicrospira.

Typical pressures in the oxidation reactor in step (c) are between 0.5 and 2 bar(g).

Preferably, the reaction medium in the oxidation reactor in step (c) is buffered. The buffering compounds are chosen in such a way that they are tolerated by the bacteria present in the oxidation reactor. Preferred buffering compounds are carbonates, bicarbonates phosphates and mixtures thereof, especially sodium carbonate and/or sodium bicarbonate. The concentration of the buffering compounds depends inter alia on the composition of the gas flow and is generally adjusted in such a way, that the pH of the reaction medium in the oxidation reactor is between 6 and 12, preferably between 7 and 11, more preferably between 8 and 10.

In step (d) of the process according to the invention at least part of the aqueous sulphur slurry obtained in step (c) is separated from the regenerated aqueous alkaline washing liquid. The phrase "at least part of" as used herein is to indicate that between 1 and 100%, preferably between 5 and 95 w/w%, more preferably between 10 and 90 w/w% of the sulphur is separated, based on the weight of the slurry.

Suitably, the separating step takes place in a solid/liquid separator. Suitable solid/liquid separators are described in Perry's Chemical Engineers' Handbook, 7th edition, section 22 (1997).

Typically, the sulphur content of the separated aqueous sulphur slurry is between 5 w/w% and 50 w/w%,

based on the slurry. Typically, the water of the sulphur slurry is removed to an extent that a sulphur cake with a dry solids content of between 55 and 70% is obtained.

Typically, the sulphur purity of the sulphur cake is  
5 between 90 and 98 w/w%, based on the dry weight of the sulphur cake. Optionally, the sulphur slurry obtained in step (c) can be re-slurried, filtered and dried to obtain a sulphur paste with a purity of at least 95 wt% sulphur, preferably at least 99 wt% sulphur. The sulphur paste  
10 thus-obtained can optionally be dried to produce a powder with a dry weight content of at least 85%, preferably at least 90%. This powder can suitably be applied as a fungicide, a fertilizer or as a miticide.

In step (e) of the process according to the  
15 invention, the regenerated aqueous alkaline washing liquid obtained in step (c) is recycled to the  $H_2S$ -removal zone in step (a) and to the mercaptan-removal zone in step (b). By recycling the regenerated aqueous alkaline washing liquid separately to the mercaptan-removal zone fresh aqueous alkaline washing liquid is  
20 supplied to the mercaptan-removal zone for the removal of the mercaptans. This enhances the removal of mercaptans to a level of 6 ppmv or less.

The process according to the invention is especially  
25 suitable for the treatment of a gaseous hydrocarbon stream, especially a natural gas stream, an associated gas stream, or a refinery gas stream. Natural gas is a general term that is applied to mixtures of inert and light hydrocarbon components that are derived from  
30 natural gas wells. The main component of natural gas is methane. Further, often ethane, propane and butane are present. In some cases (small) amounts of higher hydrocarbons may be present, often indicated as natural

gas liquids or condensates. Inert compounds may be present, especially nitrogen, carbon dioxide and, occasionally, helium. When CO<sub>2</sub> is present, also at least part of the CO<sub>2</sub> will be removed. When produced together with oil, the natural gas is usually indicated as associated gas. H<sub>2</sub>S, mercaptans, sulphides, disulfides, thiophenes and aromatic mercaptans may be present in natural gas in varying amounts. Refinery streams concern crude oil derived gaseous hydrocarbon streams containing smaller or larger amounts of sulphur compounds. Recycle streams and bleed streams of hydrotreatment processes, especially hydrodesulphurisation processes, can also suitably be treated by the process according to the invention.

Especially in the case of natural and associated gas, a considerable amount of the total amount of sulphur compounds is formed by H<sub>2</sub>S. Amounts of up to 10 or even 20 vol% or even more of H<sub>2</sub>S may be present. Further smaller or larger amounts of carbon dioxide may be present. Sometimes amounts of up to 10 or even 20 vol% or even more of carbon dioxide may be present. Suitably the gas stream comprises H<sub>2</sub>S and optionally carbon dioxide up till 2 vol%, more preferably up till 0.5 vol%.

The invention is further related to a gas-treating unit for the removal of H<sub>2</sub>S and mercaptans from a gas stream comprising these compounds in a process according to the invention.

In a typical gas-treating unit according to the invention, a gas stream comprising H<sub>2</sub>S and mercaptans is sent to a first gas scrubber. In the first gas scrubber, the gas stream is contacted with an aqueous alkaline washing liquid to remove the H<sub>2</sub>S.

The pressure in the first gas scrubber is between 1 and 100 bara, preferably between 2 and 80 bara. The temperature in the first gas scrubber is typically between 10 and 50 °C, preferably between 20 and 40 °C.

5       The first gas scrubber has a gas outlet connected to a gas discharge line, through which H<sub>2</sub>S-depleted gas leaves the scrubber and is led to the inlet of a second gas scrubber.

10       The sulphide-comprising aqueous liquid is removed from the first gas scrubber via an outlet connected to a liquid discharge line and led to the inlet of an aerobic reactor, optionally via a first flash vessel.

15       The second gas scrubber has a gas outlet, through which mercaptan-depleted gas leaves the scrubber via a gas discharge line and a liquid outlet, through which hydrocarbylsulphide-comprising aqueous liquid is led from the scrubber via a liquid discharge line to the aerobic reactor, optionally via a second flash vessel.

20       Optionally, the first and second gas scrubber may be placed on top of each other in one vessel.

25       The aerobic reactor has an outlet through which a sulphur slurry is led to a solid/liquid separator. The solid/liquid separator has a liquid outlet through which regenerated aqueous alkaline washing liquid is led via discharge lines to the first gas scrubber and to the second gas scrubber.

30       The invention will now be illustrated by means of schematic figure 1. Figure 1 depicts a typical process scheme according to the invention, wherein a gas stream comprising H<sub>2</sub>S and mercaptans enters the first scrubber (2) via line (1) and is treated with the aqueous alkaline washing liquid to remove the H<sub>2</sub>S. After treatment in the first gas scrubber, the H<sub>2</sub>S-depleted gas

stream leaves the first gas scrubber via line (3) and enters the second gas scrubber (4) where it is treated with some aqueous alkaline washing liquid to remove the mercaptans. After treatment in the second gas scrubber, the mercaptan-depleted gas stream leaves the second gas scrubber via line (5). A sulphide-comprising aqueous stream leaves the first gas scrubber via line (6) and enters a first flash vessel (7a). The hydrocarbyl-sulphide-comprising aqueous stream leaves the second scrubber via line (8) and enters a second flash vessel (7b). Hydrocarbon-containing excess gas is vented off from the flash vessels (7a) and (7b) through lines (9a) and (9b). The liquid stream comprising sulphides and hydrocarbylsulphides is led via lines (10a) and (10b) to the aerobic reactor (11) where the sulphide compounds are oxidised. Nutrients and air are fed to the aerobic reactor via feed lines (12) and (13). Part of the sulphur-containing solid/liquid mixture generated in the aerobic reactor is led via line (14) to a solid/liquid separator (15) where the solid sulphur is separated and discharged via line (16) and the liquid is led back to the bioreactor via line (17). Off-gas is vented from the aerobic reactor via line (18). The regenerated aqueous alkaline washing liquid, comprising sulphur particles, is led to the first gas scrubber via line (19) and to the second gas scrubber via line (20).

Experiments were conducted for the removal of  $H_2S$  and mercaptans from a natural gas stream comprising these compounds. The flow rate of the gas stream was measured and the solvent flow rate was kept at a fixed value. In the comparative examples, the gas stream was contacted with aqueous alkaline washing liquid in a gas scrubber. The amount of  $H_2S$ , mercaptans and  $CO_2$  of the gas stream

was measured prior to entering the gas scrubber and after leaving the gas scrubber. In the examples according to the invention, the gas stream was treated in a process according to the invention. The amount of H<sub>2</sub>S, mercaptans and CO<sub>2</sub> of the gas stream was measured prior to entering the H<sub>2</sub>S removal zone and after leaving the mercaptan removal zone.

EXAMPLE 1 (comparative)

Flow rate of the natural gas stream: 180000 Nm<sup>3</sup>/day, pressure in the gas scrubber: 50 bar(g). Gas stream prior to entering the gas scrubber: 0.5 vol% H<sub>2</sub>S, 2 vol% CO<sub>2</sub> and 25 ppmv RSH. Gas stream leaving the gas scrubber: H<sub>2</sub>S below 3 ppmv, RSH 14.7 ppmv.

EXAMPLE 2 (according to the invention)

Flow rate of the natural gas stream: 180000 Nm<sup>3</sup>/day, pressure in the gas scrubber: 50 bar(g). Gas stream prior to entering H<sub>2</sub>S removal zone: 0.5 vol% H<sub>2</sub>S, 2 vol% CO<sub>2</sub> and 25 ppmv RSH. Gas stream leaving the mercaptan removal zone: H<sub>2</sub>S below 3 ppmv, RSH 3.4 ppmv.

EXAMPLE 3 (comparative)

Flow rate of the natural gas stream: 400000 Nm<sup>3</sup>/day, pressure: 65 bar(g). Gas stream prior to entering the gas scrubber: 1 vol% H<sub>2</sub>S, 1 vol% CO<sub>2</sub>, 30 ppmv RSH. Gas stream leaving the gas scrubber: H<sub>2</sub>S below 3 ppmv, RSH 25.9 ppmv.

EXAMPLE 4 (according to the invention)

Flow rate of the natural gas stream: 400000 Nm<sup>3</sup>/day, pressure: 65 bar(g). Gas stream prior to entering the H<sub>2</sub>S removal zone: 1 vol% H<sub>2</sub>S, 1 vol% CO<sub>2</sub>, 30 ppmv RSH. Gas stream leaving the mercaptan removal zone: H<sub>2</sub>S below 3 ppmv, RSH 4.1 ppmv.



From the examples it is shown that the process according to the invention results in a much lower level of mercaptans than the comparative process.

C L A I M S

1. A process for the removal of H<sub>2</sub>S and mercaptans from a gas stream comprising these compounds, which process comprises the steps of:

5 (a) removing H<sub>2</sub>S from the gas stream by contacting the gas stream in a H<sub>2</sub>S-removal zone with a first aqueous alkaline washing liquid to obtain a H<sub>2</sub>S-depleted gas stream and a sulphide-comprising aqueous stream;

10 (b) removing mercaptans from the H<sub>2</sub>S-depleted gas stream obtained in step (a) by contacting the H<sub>2</sub>S-depleted gas stream in a mercaptan-removal zone with a second aqueous alkaline washing liquid to obtain a mercaptan-depleted gas stream and an hydrocarbylsulphide-comprising aqueous stream;

15 (c) contacting the combined aqueous streams comprising sulphide and hydrocarbylsulphides obtained in step (a) and step (b) with sulphide-oxidizing bacteria in the presence of oxygen in an oxidation reactor to obtain a sulphur slurry and a regenerated aqueous alkaline washing liquid;

20 (d) separating at least part of the sulphur slurry obtained in step (c) from the regenerated aqueous alkaline washing liquid; and

25 (e) recycling the regenerated aqueous alkaline washing liquid obtained in step (d) to the H<sub>2</sub>S-removal zone in step (a) and to the mercaptan-removal zone in step (b).

2. A process according to claim 1, wherein step (a) and/or step (b) take place in a gas/liquid contactor.

3. A process according to claims 1 or 2, wherein the washing liquid in step (a) is buffered, preferably at a pH of between 4.5 and 10, more preferably at a pH between 5.5 and 9.

5 4. A process according to any one of claims 1 to 3, wherein the washing liquid in step (b) is buffered, preferably at a pH of between 5.5 and 10, more preferably at a pH between 6.5 and 9.

10 5. A process according to any one of claims 1 to 4, wherein the contents of the oxidation reactor in step (c) is buffered, preferably at a pH between 5.5 and 10, more preferably between 6.5 and 9.

15 6. A process according to any one of claims 1 to 5, wherein the H<sub>2</sub>S load in the H<sub>2</sub>S-removal zone in step (a) is between 50 and 100000 kg/day, preferably between 100 and 50000 kg/day.

20 7. A process according to any one of claims 1 to 6, wherein the H<sub>2</sub>S concentration of the gas stream entering the H<sub>2</sub>S-removal zone in step (a) is between 50 ppmv and 90 vol%, preferably between 100 ppmv and 70 vol%, more preferably between 150 ppmv and 50 vol%.

25 8. A process according to any one of claims 1 to 7, wherein the H<sub>2</sub>S concentration of the mercaptan-depleted gas stream is less than 10 ppmv, especially between 0.01 and 10 ppmv, preferably between 0.05 and 3.5 ppmv, more preferably between 0.1 and 1 ppmv, based on the total mercaptan-depleted gas stream.

30 9. A process according to any one of claims 1 to 8, wherein the mercaptan concentration of the H<sub>2</sub>S-depleted gas stream entering the mercaptan-removal zone in step (b) is between 1 ppmv and 0.3 vol%, preferably between 10 ppmv and 0.1 vol%, based on the total H<sub>2</sub>S-depleted gas stream.

10. A process according to any one of claims 1 to 9,  
wherein the concentration of mercaptan compounds is less  
than 6 ppmv, preferably less than 4 ppmv, more preferably  
less than 2 ppmv, based on the total mercaptan-depleted  
gas stream.

5

11. A process according to any of claims 1 to 10, wherein  
the oxidation reactor in step (c) has a volume of between  
5 and 2500 m<sup>3</sup>.

12. A process according to any of claims 1 to 11, wherein  
the sulphur slurry obtained in step (c) is re-slurried,  
filtered and dried to obtain a purity of at least 95 wt%  
sulphur, preferably at least 99 wt% sulphur.

10

13. A gas-treating unit for the removal of H<sub>2</sub>S and  
mercaptans from a gas stream comprising these compounds  
in a process according to any of the preceding claims,  
the section comprising at least two gas scrubbers with  
inlets and outlets, at least one aerobic reactor with  
inlets and outlets and a solid/liquid separator with an  
inlet and outlets, the first gas scrubber having a  
discharge line for gas debouching into the inlet of the  
second gas scrubber, the first and the second gas  
scrubbers both having a discharge line for liquid  
debouching into the inlet of the aerobic reactor,  
optionally via a first and a second flash vessel,  
respectively, the aerobic reactor having an outlet  
debouching into the inlet of the solid/liquid separator,  
the solid/liquid separator having an outlet for liquid  
debouching into the inlet of the first gas scrubber and  
an outlet for liquid debouching into the inlet of the  
second gas scrubber.

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14. A section according to claim 13, wherein the first  
and the second gas scrubber are placed on top of each  
other in one vessel.

15. A section according to claim 13 or 14, wherein the discharge line for liquid of the first gas scrubber and the discharge line for liquid of the second gas scrubber are connected to a first and a second flash vessel, respectively, both flash vessels having discharge lines debouching into the aerobic scrubber.

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16. A section according to claim 15, wherein the two flash vessels are placed on top of each other in one vessel.

A B S T R A C T

A PROCESS FOR THE REMOVAL OF  $H_2S$  AND MERCAPTANS FROM A  
GAS STREAM

The invention relates to a process for the removal of  $H_2S$  and mercaptans from a gas stream comprising these compounds, which process comprises the steps of:

- (a) removing  $H_2S$  from the gas stream by contacting the gas stream in a  $H_2S$ -removal zone with a first aqueous alkaline washing liquid to obtain a  $H_2S$ -depleted gas stream and a sulphide-comprising aqueous stream;
- (b) removing mercaptans from the  $H_2S$ -depleted gas stream obtained in step (a) by contacting the  $H_2S$ -depleted gas stream in a mercaptan-removal zone with a second aqueous alkaline washing liquid to obtain a mercaptan-depleted gas stream and an hydrocarbylsulphide-comprising aqueous stream;
- (c) contacting the combined aqueous streams comprising sulphide and hydrocarbylsulphides obtained in step (a) and step (b) with sulphide-oxidizing bacteria in the presence of oxygen in an oxidation reactor to obtain a sulphur slurry and a regenerated aqueous alkaline washing liquid;
- (d) separating at least part of the sulphur slurry obtained in step (c) from the regenerated aqueous alkaline washing liquid; and

(e) recycling the regenerated aqueous alkaline washing liquid obtained in step (d) to the H<sub>2</sub>S-removal zone in step (a) and to the mercaptan-removal zone in step (b).

The invention further relates to a gas-treating unit for the removal of H<sub>2</sub>S and mercaptans and from a gas stream comprising these compounds in a process according to the invention.

(Figure)

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